IS VENUS INHABITED?

BY

C. E. HOUSDEN

MEMBER B.A.A.

WITH DIAGRAMS

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IS VENUS INHABITED?

In this pamphlet are put forward for consideration some theories formed with regard to the probable physical condition of Venus, from a study of recorded observations of the planet and of its surface markings.

The views advanced herein will doubtless, at first reading, appear somewhat startling as they postulate the probable existence of intelligent life on our neighbour world. The arguments on which they are based will, nevertheless, it is hoped, be found to be sound, and the deductions therefrom reasonable.

The diameter of Venus is about 7630 miles, and its density but just inferior to that of our Earth, 0·82 to 1. The planet thus much resembles our own dwelling place in size and mass and, therefore, probably in its admitted atmospheric equipment.

According to Dr. Lowell its physical condition must, however, be radically different.

From his study of Venus, and of its surface markings (which markings he finds are very faint, but nevertheless assurable and keep an invariable position to one another), he has come to the following conclusions with regard to the planet :—

(i.) It always turns the same face to the Sun, its dark hemisphere must in consequence be intensely cold and the sunlit one an arid desert.

(ii.) The amount of water vapour which can be spectroscopically detected overlying its sunlit face is small.

(iii.) The Venusian atmosphere is a cloudless but probably a dust-laden one.

(iv.) The planet's high albedo, or power of reflecting 92 per cent. of incident light, is due to its cloudless but dust-charged atmosphere ; and finally—

(v.) All we know on Earth as life is, for the above reasons, unlikely thereon.

It appears probable, however, as is shown later on, that the planet's actual physical

condition may in some respects differ from the above outline thereof.

The surface markings of Venus are, Dr. Lowell finds, somewhat peculiar in character; they are generally, if somewhat roughly and too markedly, indicated in Fig. (1), Plate I., which has been prepared from a consideration of his published views of the planet when it is near superior conjunction, the use of which he has kindly allowed for this purpose.

It will be seen from this illustration that these markings consist of—

(*a*) Finger-like shadings running in spoke-wise fashion from the planet's bright terminator towards the centre of the illuminated disc.

(*b*) Some further shaded areas around this centre, and—

(*c*) A sort of collar round the southern cusp.

It will be further noticed that the spoke or finger-like markings are strongest and widest near the terminator, where their width is about 500 miles as scaled from Dr. Lowell's drawings.

(The existence of such markings has been generally confirmed by the Mercury and Venus

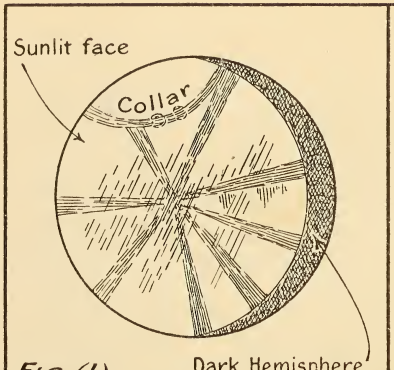

FIG. (1).

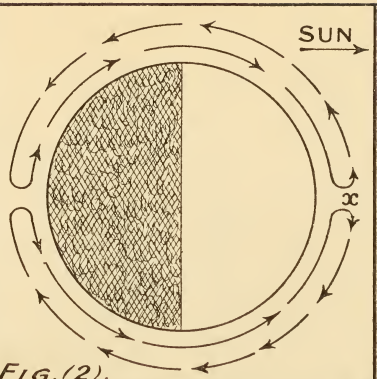

FIG. (2).

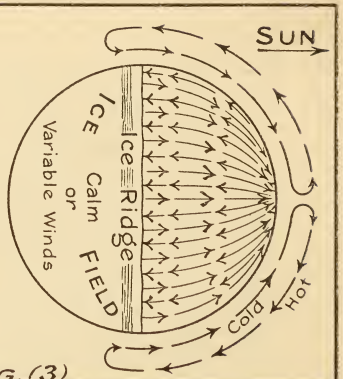

FIG. (3).

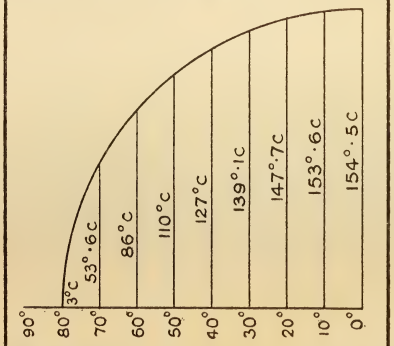

FIG. (4).

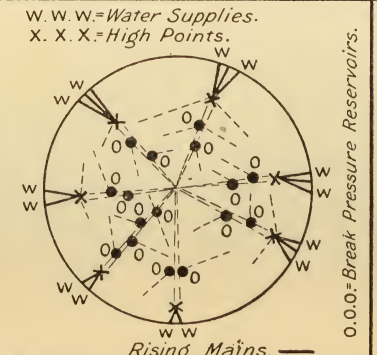

FIG. (5).

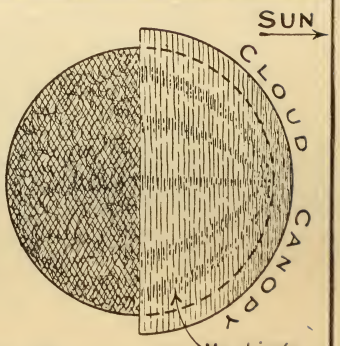

FIG. (6).

Section of the British Astronomical Association, *vide* Annual Report for 1913–1914, page 504.)

Dr. Lowell suggests in "The Evolution of Worlds," that as the aerial circulation of Venus is, on the assumption that the planet always turns the same face to the sun, most probably, somewhat as illustrated in Fig. (2), the planet's surface would be swept by winds of hurricane power, flowing across the terminator of the sun-lit face from the dark to the sun-illumined hemisphere, the marks of whose inrush might well be discernible as the finger-like markings even across the great distance which separates Venus from our Earth when the planet is at superior conjunction. This theory does not, however, afford any explanation of the planet's other markings and, moreover, does not appear to be in other ways sufficiently full, an alternative one is, therefore, now advanced.

In the first place air rushing inwards to a central point where the barometric pressure is low would not progress in direct lines, but would have a spiral inflow, and in the next place to scour the planet's surface with finger-like markings by an inrush of air from its terminator the

force of the uprush of air at the centre of the sunlit face would have to be very great indeed, for in Venus we have to deal with a globe whose diameter is close on 7650 miles, and which has, in consequence, a circumference of about 24,000 miles.

If the shaft (x in Fig. (2)) up which the air is rising in the centre of the illuminated disc has a circumference of 1000 miles (diameter 318·3 miles), into which the air is flowing from all sides at a rate of 100 miles per hour, the rate at which the air would have to move centrewards from the outer edge of the sun-illumined face would at most be $\frac{100}{24}$, or say about 4 miles per hour only.

For the air to rush across the dividing line between the dark and bright hemispheres at even 40 miles an hour, the uprush at the centre of the bright hemisphere and, what is more, the down-flow at the centre of the dark hemisphere would have to reach the very great velocity of well over 1000 miles per hour. No such general high velocity in air movements has been recorded on our own Earth, whose atmosphere is probably similar to that of Venus, wind velocities even in

violent hurricanes, which are clearly due to local causes, but seldom exceeding 100 miles per hour.

To help us form some conclusions with regard to the general probable circulation of the atmosphere of Venus a review, without going into too much detail, of conditions regulating the systematic flow of air on Earth will perhaps be of assistance.

Owing to the heated condition of Earth's equatorial regions, or from some other cause, the air immediately overlying them rises causing, to replace the air thus displaced, a flow of air equatorwards from the direction of the Poles, which flow of air the rotation of the Earth on its axis converts into north-easterly trade winds north of the Equator and south-easterly trade winds south of it. The heated air rising in the equatorial regions flows over these trade winds in polewards directions to begin with, to be, owing again to the earth's rotation, diverted into south-westerly winds north of the Equator and north-westerly ones south of it. Both these latter air currents do not, however, get as far as the Polar regions—north or south

—but being checked, by running into a colder atmosphere and one having a smaller circumference, are brought down to the Earth's surface in about latitude 30° to 40° north and south, to thence flow back as surface currents equatorwards. The regular flow of air above outlined being between these latitudes north or south and the corresponding poles replaced by a region of variable winds.

Something of the same kind, it would appear, very probably takes place on Venus also, but owing to no great change in temperature being met with until the dividing line between the illuminated and dark hemispheres is crossed, and owing to the upper air currents flowing into regions having an ever increasing circumference until this dividing line is crossed, it is very likely that they do not come to the surface of Venus until a girdling circle a short distance within the planet's dark hemisphere is reached. The general flow of air on the planet being thus, it is suggested, somewhat as shown in Fig. (3), in which the lengths of the arrows indicate decreasing and increasing velocities. The directions of flow would also

probably have a more spiral set than that indicated in the cut.

The heights of the air currents are also much exaggerated in this sketch. They would probably be limited to the lower portions of the planet's atmosphere, the depth of which on Venus might be about 3 to 4 miles, the lower flow being approximately confined to the lower $1\frac{1}{2}$ to 2 miles and the upper flow to the upper $1\frac{1}{2}$ to 2 miles, the length of either current being over 6000 miles.

The effect of such an air circulation would be the same as that of the circulation suggested by Dr. Lowell, all moisture would in time be evaporated from the planet's hemisphere exposed to perpetual sunshine and deposited as ice on the planet's dark hemisphere. This deposit of ice would, however, most probably be greatest and thickest at a short distance inside the outer boundary of the dark hemisphere as illustrated in Fig. (3).

We should thus have in the planet's dark hemisphere a vast ice field with a more or less connected series of glaciers along its outer edge and at no great distance from the

planet's ever illumined face. This series of glaciers would be of an unknown but not great width; it would, however, have a total face length of close on 24,000 miles. The ice composing these glaciers would under the action of gravity, and also probably under the influence of the hot current of descending air, be forced down existing valleys into the sunlit face or at any rate into a temperature of over 32° F. to there melt and flow down the glacier valleys as water.

The water so made available could not, however, under normal conditions flow very far into the hemisphere of Venus exposed to perpetual sunshine without being all evaporated into the planet's atmosphere to be carried as cloud or water vapour back by the upper air currents to the glaciers whence it was derived.

The Rev. M. Davidson has kindly calculated for me the probable temperatures at 10° intervals on the hemisphere of Venus in perpetual sunshine on the assumption that the planet like the Earth radiates heat more or less like a "dark body." These temperatures are shown in the half curve illustrated in Fig. (4).

It will be seen from this curve that all water flowing from the dark to the bright hemisphere would be literally boiled off the planet's surface before getting much more than 30° within the sunlit face. Thirty degrees on a globe the circumference of which is 24,000 miles represent a distance of 2000 miles. It is clear, however, from this diagram that next the melting ice there would be a strip of land 24,000 miles long and at least 1000 miles wide, comprising an area of 24,000,000 square miles on which water would be always available and the temperature of which would range from 0° C. to 50° C., *i.e.* 32° F. to 122° F. On this strip of the planet's surface life as we know it on Earth would consequently be possible if the Venusian atmosphere is similar in composition to our own, as is very likely the case. This much can be inferred on general grounds without a consideration of any of the planet's markings. Markings, however, as we have seen, there are, and we may learn something further from studying them.

Imagine now an enterprising race in occupation of this narrow strip of Venus' surface and desirous of extending the area of their

domain. At their back the inhabitants thereof would have an inexhaustible ice field which, if not melting off sufficiently quickly naturally, could be artificially melted to any desired extent, thus providing a practically unlimited supply of fresh water of which they could make use in the reclamation of the outlying arid areas.

This water could not, on account of rapid evaporation, be carried in open channels very far into the lands it is desired to reclaim.

It could, however, be carried forward by gravitation down the perhaps circuitous valleys in which the water flows in covered pipes or conduits to any desired points therein a good deal lower than the points at which the flowing water is available, as the head needed to force the water through pipes or conduits of moderate dimensions would be considerable. This would naturally limit the areas to which water could be so delivered. To economically raise it out of the valleys to the planet's higher lands, it would be necessary to pump it up to them. The lower down the valleys the first pumping stations were placed the greater would be the lift to the higher lands. It would therefore be advisable to

commence pumping the available supplies as early as possible, *i.e.* from points as near as possible to the melting glaciers. If it is desired to pump the water out to some point near the centre of the illuminated disc on much the same level as the source of supply the simplest and most economical method would be to carry the line of pipes which would be needed for such a purpose in the easiest direct line over hill and dale, for the simple reason that the power needed in such case would be much the same as that which would be needed for pumping in a direct line the same quantity of water through the same sized pipes over level ground, supposing always that such a direct level line could be obtained, which is extremely unlikely.

The above would be the case because power lost in overcoming an intervening height or heights would be regained on the down grades.

Another advantage in carrying such a line of pipes in a direct line over intervening heights would be that from each such high point passed over water could be distributed in all directions to lower lands commanded by it through pipes or conduits under static pressure. Open channels

for such distribution would result in much loss of water from evaporation.

One possible and economical system for the distribution of water through pipes to a small circular area from low-lying sources of supply situated at different points on its circumference would be that illustrated in Fig. (5).

If the quantity of water to be so pumped and distributed is great, the number of pipes needed for its conveyance would, to begin with, be large, their number being gradually reduced as a portion of the water flowing through them is distributed to the lower-lying areas by means of pipes under static pressure taking off from the high points passed over by the main line of pipes.

A comparison of Fig. (5) with Fig. (1) suggests that water is probably so distributed over the sunlit face of Venus, and that also in very large quantities, and thus postulates the existence of *intelligent* life on the planet. One result of such a distribution of water over the planet's bright hemisphere would be rapid evaporation therefrom or from the vegetation

produced thereby. The evaporation would be greatest where the heat is greatest, *i.e.* at the centre of the planet's sunlit face, and would gradually decrease towards its circumference. Such evaporation would probably result in the formation of a cloud cap of some sort over the planet's bright hemisphere somewhat as shown in Fig. (6), through narrow openings in which cloud canopy the dark markings of the planet would show faintly; the density of this cloud cap over each square unit of the sunlit hemisphere gradually getting less and less pronounced the greater the distance towards the terminator from the centre of the illuminated disc. This would account for the increasing faintness of all Venusian markings from the bright terminator centrewards.

Now if it can be shown from other evidence that such a cloud cap does probably cover Venus' sunlit face, it is only a reasonable assumption that it has been produced by water regularly distributed over the planet's sunlit disc in the manner already suggested, *i.e.* by being pumped, from where it is available near the planet's sunlit terminator, through

water-tight pipes or conduits in the directions indicated by the finger-like markings and distributed from these pipes or conduits over the areas covered by these markings as well as over other shaded areas to be seen on Venus: the finger-like markings and other shaded areas being thus the planet's artificially irrigated lands dimly seen through a perpetual veil of dense cloud (see Fig. (6)). As such a veil of *unbroken cloud* would if it there existed cut off about four-fifths of the heat reaching the planet from the Sun, the temperature at the centre of the illuminated disc would be reduced, and the temperature all over this disc be probably in consequence quite moderate. With, however, narrow but extensive breaks in this cloud canopy, which is more likely to be its actual formation, the temperature of the cloud-covered areas would very likely be still quite bearable though doubtless well on the *hot* side, and even perhaps super-tropical and dry at that.

All heat getting through to the Venusian surface and trapped by the more or less open cloud canopy on reflection from this surface would be probably considerably modified by the

cold lower currents flowing from all sides to the centre of the sunlit face.

With regard to the probable existence of clouds in the planet's atmosphere the following quotation from the article on Venus in the "Encyclopædia Britannica" is of interest.

"Other observations than those we have cited above show that Venus is surrounded by an atmosphere so filled with clouds that it is doubtful whether any view of the solid body of the planet can ever be obtained. The first evidence in favour of an atmosphere was found in the fact that when near inferior conjunction the visible outline of the thin crescent extended through more than 180°. Most remarkable was an observation by Charles Smith Lyman at New Haven during the conjunction of 1866 when the planet was just without the Sun, a thin line of light was supposed to be seen all round the limb of the planet most distant from the Sun. But as no such appearance was seen during the approach of the planet to the Sun at the transit of 1874 and 1882, when conditions were much more favourable, it seems likely that such objects are the result of an optical illusion. During the

latter of the two transits the phenomena of this class observed were of an unexpected character. Not a trace of the planet could be seen until it began to impinge on the solar disc. When about one-half of its diameter had entered upon the Sun the outline outside the disc of the Sun began to be marked by broken portions of an arc of light. This did not begin at the point A (Fig. (*a*), Plate III., page 26) furthest from the Sun, as it should have done if due wholly to refraction, but immediately at the Sun itself, as shown in the cut at the point B. Portions of this arc were formed one by one at various other points of the dotted outline, and when the planet was about three-fourths on the Sun it was completed, but there was no strengthening of the line at the middle point as there should have been if due to refraction. Yet refraction must have played some part in the phenomenon because otherwise no illumination could have been visible under the circumstances. The most satisfactory explanation appears to be that of H. N. Russell, whose conclusion is that the atmosphere is so permeated with fine particles of water vapour up to its outer limit as to be only translucent

without being fully transparent. Thus what is seen is the irregular reflection of light at an extremely small angle from the particles of vapour."

It would appear, however, that the phenomena above recorded, as well as the want of them, could be better explained by the existence of a dense cloud cap of a high-lying cumulus (rainless) type floating over nearly the entire illuminated disc of Venus, about 1 to $1\frac{1}{2}$ miles up in its atmosphere, or say at a height of between 5000 and 8000 feet. Cumuli are on Earth essentially day clouds, forming about 11 a.m. and dissipating again towards evening, and as it is always day on Venus' bright face, midday at its centre and what would correspond to morning or evening on Earth at its terminator, such a type of clouds would probably be confined to the inner portion of this face and be always there present. According to the "Encyclopædia Britannica": "Cumulus clouds are thick clouds of which the upper surfaces are dome-shaped, and exhibit protuberances, while the base is horizontal. These clouds appear to be formed by a diurnal

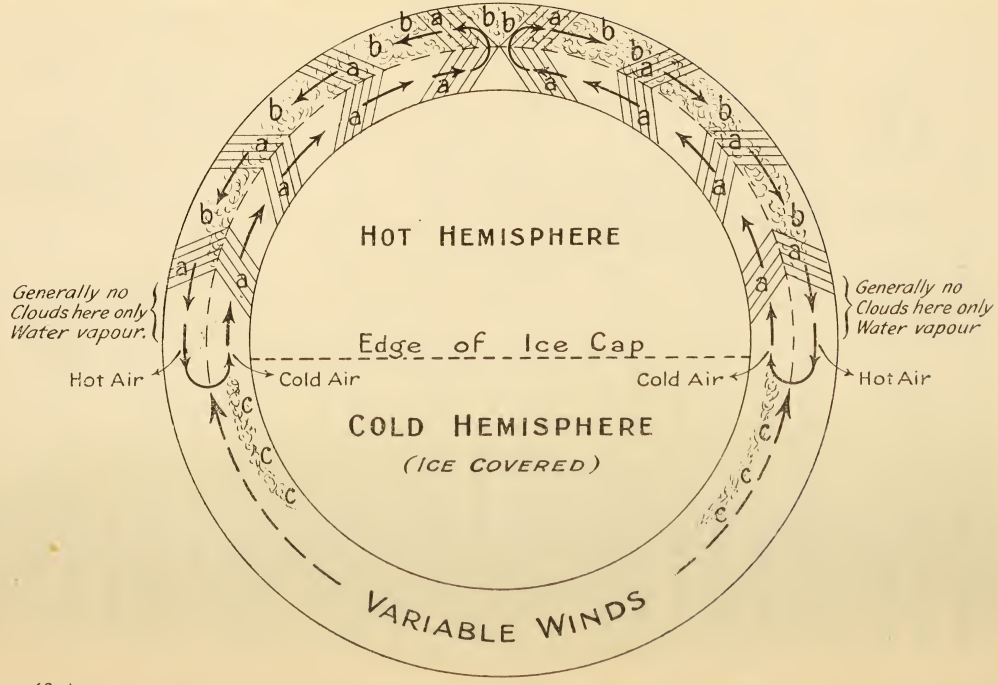
HOT HEMISPHERE
Edge of Ice Cap
COLD HEMISPHERE
(ICE COVERED)
VARIABLE WINDS
Generally no Clouds here only Water vapour.
Generally no Clouds here only Water vapour
Hot Air
Cold Air
Cold Air
Hot Air
a
b
c

FIG. (6a).

ascensional movement, which is almost always observable. When the cloud is opposite the Sun the surfaces usually presented to the observer have a greater brilliance than the margin of the protuberances."

In other words sunlight filters horizontally through such clouds to some extent.

The formation of such clouds on Earth, where two layers of air of different density slide against each other by being carried in opposite directions, is well authenticated. Taking all the points above referred to into consideration, it is suggested that the arrangement of clouds on Venus may be somewhat as illustrated in Fig. (6*a*), Plate II., which represents a section through the planet and its atmosphere, where :—

aaa. Are ascending air currents charged with water vapour, which is eventually carried from Venus' bright hemisphere to its dark one.

bbb. Is the suggested cumulus cloud canopy.

ccc. Are low-lying rain or snow clouds in the planet's dark hemisphere.

The great whiteness of the cumulus clouds might in part help to account for the planet's high albedo, the balance of light reflected being

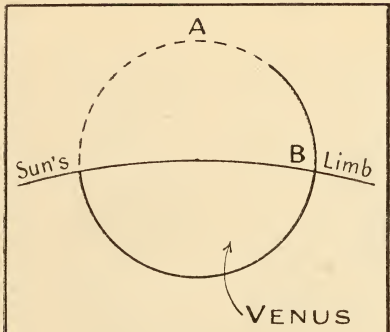

FIG. (a).

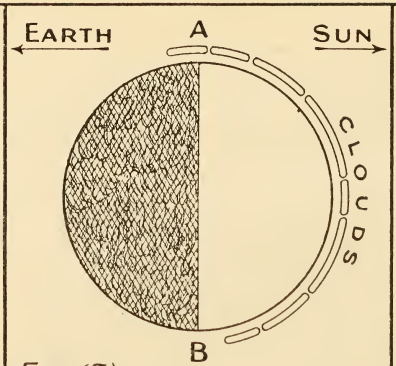

FIG. (7).

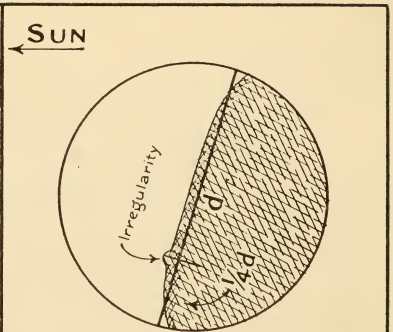

FIG. (8). 15th Feby 1913.

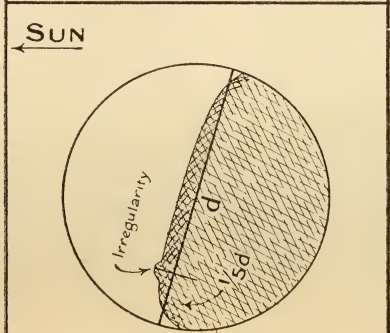

FIG. (9). 19th Feby 1913.

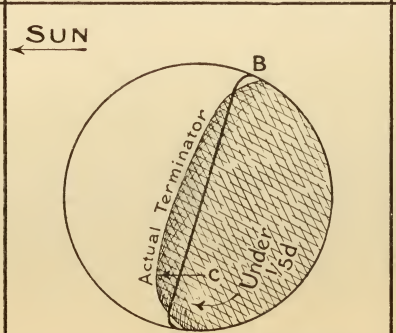

FIG. (10). A-B = Theoretical Terminator. 22·2·'15.

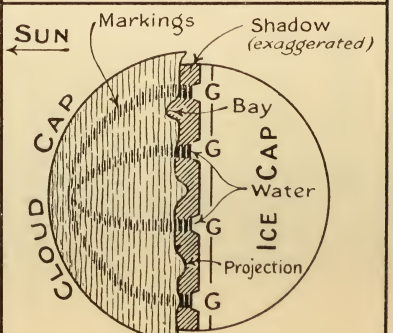

FIG. (11). G.G. = Glaciers.

reflected from the planet's atmosphere above the cloud canopy.

When, at a time when the planet is very close to the Sun at inferior conjunction or is about to transit, the cumulus cloud cover extends beyond Venus' sunlit face a short distance into its dark hemisphere, as at A in Fig. (7), Plate III. (which would probably be very rarely the case), the Sun's light would shine through, or be reflected from the lower sides of, the cumuli. When, however, the cloud covering does not extend into the dark hemisphere as at B, nothing would be seen.

That such a cloud cap does cover Venus' sunlit face, and that it does not always extend to its terminator is, it would appear probable, supported by Mr. McEwen's paper on "Large irregularity on the terminator of Venus," which appeared in the *Journal of the British Astronomical Association* for April, 1913 (pp. 325 to 327).

It was a study of this article which first suggested the probable existence over Venus' sunlit hemisphere of such a cloud canopy as that above outlined.

The irregularity referred to by Mr. McEwen,

the existence of which was independently corroborated by Mr. Sargent of Bristol, is illustrated in the outline Figs. (8), (9) and (10), Plate III., sketched, with his kind permission and the sanction of the Council of the British Astronomical Association, from three of the illustrations to Mr. McEwen's paper. Here we have (Figs. (8) and (9)) an extensive marking about $300 \times 200 = 60{,}000$ square miles in area, which had clearly moved in four days along Venus' terminator at eastern elongation, for a distance of $\frac{1}{4}$th $- \frac{1}{5}$th $= \frac{1}{20}$th of the planet's half circumference, or at a rate of $\frac{\frac{1}{20} \times 12000}{4 \times 24} = 6$ miles per hour, and may well have been a large bay in the edge of a drifting cloud canopy. This bay had, see Fig. (10), completely disappeared three days later, though the position in which it had existed was still marked by a wide bend in the planet's illuminated terminator. Mr. McEwen's paper further shows that this illuminated terminator was on the date of the latter observation $\frac{1{\cdot}3}{27{\cdot}6} \times 12000 =$ practically 600 miles inside the planet's theoretical terminator.

In connection with this observation, Mr. McEwen remarks: "It is profoundly interesting to compare these two lines, the one showing the actual terminator and the other indicating the position of the theoretical terminator. This is, of course, another way of expressing the well-known fact that Venus presents a crescent at maximum elongation when it should be dichotomised."

Mr. McEwen's observations and the "fact that Venus presents a crescent at maximum elongation," can be well explained by the existence of a closely packed cloud canopy over the sun-illumined hemisphere, which cloud canopy does not always extend to the planet's theoretical terminator. The continuous cloud canopy would be illuminated by the Sun's rays, the part of the planet's sunward hemisphere next the theoretical terminator being, as shown in Fig. (11), in shadow.

That the cloud canopy does occasionally extend beyond the general sunlit terminator is supported by projections therefrom, which are at times 200 miles long and 100 miles wide, and may thus well be banks of cloud extending away

from this terminator (see illustrations of Venus in Dr. Lowell's "The Evolution of Worlds").

If then such a cloud canopy does exist over the sun-illuminated face of Venus, and the evidence above cited goes to show that there is something more than mere dust and water vapour in the planet's atmosphere, why has Dr. Lowell observed no clouds? This can perhaps be accounted for by his possibly being on the look out for rapidly moving and not closely packed clouds, whereas the planet's cloud covering is probably practically continuous, and its movement is most likely, especially near the terminator, comparatively slow, as has been seen above was probably the case in the large irregularity brought to notice by Mr. McEwen.

The spectroscope would, under the assumed conditions, indicate but little water vapour on Venus' sunlit face, as the air above the perpetual dense cloud canopy, which reflects the Sun's light, would be comparatively dry.

To secure the continued existence of such a cloud canopy, water must in some way be regularly supplied to the sun-illuminated hemisphere, and this could only, it is suggested, be

effected by its being pumped to suitable localities from water supplies which are very probably obtainable from the vast ice-fields of the planet's dark hemisphere.

The finger-like markings reaching in from the terminator would appear to indicate the directions and localities in which the water is so pumped.

If these markings were viewed through a dust-laden atmosphere, when the planet is near superior conjunction, they should be either entirely obliterated near the planet's terminator or be very faintly seen. That they here show darkest would appear to indicate that they are next the illuminated terminator seen through an atmosphere to a great extent free of dust, and also of the cloud canopy which probably covers the rest of the planet's sunlit disc and which grows denser towards the centre of this sunlit face (see Fig. (6*a*)).

The collar round the southern cusp can be explained by the existence here of a group of high mountains, the water flowing from the glaciers situated in the valleys thereof collecting at the foot of such mountain group, and being

there used in part for local irrigation and in part pumped on towards the centre of the illuminated disc along the finger-like markings leading from this collar (Fig. (1)).

These Venusian finger-like markings are thus very probably similar in some ways to the "Canals of Mars" as in "The Riddle of Mars" they have been theorised to be. In both cases the markings may well indicate the directions in which water is being pumped a long distance for the purpose of irrigation through groups of pipes. On Venus there is a large and continuous drain on the water being so pumped, hence the markings gradually decrease in width the further they go. On Mars, on the contrary, the drain for local use on the water carried in its pipes is very small until the service reservoirs, from which the planet's extensive blue-green areas are possibly irrigated by a vast system of irrigation pipes under static pressure, are reached. The Martian canals are therefore of the same width throughout.

One set of markings would thus appear to corroborate the other. On each planet a fight for existence, but with in each case a different

object in view, would appear to be in progress. On Mars the conservation for irrigation of a scanty water supply, on Venus the irrigation from a plentiful, but readily evaporable, water supply of portions of its sunlit hemisphere, resulting in the formation over this face of a more or less continuous cloud canopy helping to temper the great heat to which it would otherwise be subjected. Behind both systems may be perceived the working of a high order of intelligence.

How far these views will meet with general acceptance time alone can show, new theories generally having to make their way and justify their conception.

The suggestions now advanced are based on the principles of hydraulics, with which few are well acquainted; speaking generally, mundane experience in dealing with questions of water supply shows, however, that where water cannot be conveyed from where it is available to where it is needed, through the air as water vapour or by gravitation through pipes or channels, the simplest and most economical method of conveying it is to

pump it. To devise means for effecting this on a large, but not impossible, scale postulates the existence of life and of a superior intelligence on both our neighbour worlds, and to this conclusion it is submitted we are driven by a study of the surface markings of both planets and the special features and characteristics of these markings. The markings are there and we must do our best to find a reasonable explanation for them.

The very positioning, implying *plan*, of the very long, very straight and, in comparison with their length, very narrow markings of both Venus and Mars suggests *inter alia* their probable artificial nature and their possible true character—tracts, along or over which water is being pumped or otherwise carried in pipes or conduits under pressure rendered visible owing to the existence thereon of the necessary pumping stations and the irrigation of the gardens, fields, etc., in the immediate neighbourhood of these stations as well as along the pipe lines themselves, and on lands adjacent thereto.

An estimate of the pump horse-power which would probably be needed to cover all Venus'

dark markings, so far recorded, with an 18-inch depth of water in 12 mundane months will be found in the Appendix. It works out to $HP = 17 \times 10^9$, which is probably much under that in daily use on Earth. There is therefore no impossibility involved in such a system of water distribution as that above outlined being in use on Venus, especially as the above estimate is most probably an outside one.

It would appear to be, both in the case of Venus and in that of Mars, a mere question of special conditions of demand and supply, which would have to be faced and overcome in much the same way by man were he placed under similar conditions. He would merely be adopting in both cases on a vast and extensive scale a system of water carriage already in use in many cases on earth on, comparatively, a much smaller one.

Very likely it is due to the great magnitude of the operations which would be needed that we can perceive any signs of such systems being probably in operation on both planets.

It is, to say the least, very singular that *all* the markings so far recorded on both Venus

and Mars, including the latter's celebrated "double canals," can be satisfactorily accounted for on the assumption that large quantities of water have to be pumped long distances on each planet from where water is, as far as we can judge, available in sufficient amount to where it can probably be usefully utilized for irrigation. The conveyance of water in this way being, as mundane experience has shown, not only possible but financially profitable.

In conclusion it is sincerely hoped that even if the suggestions now advanced with regard to the probable physical condition of Venus do not find general acceptance, this paper will at any rate stimulate the study of the planet with a view to the collection of further evidence for or against them; also that the definite and precise, and therefore if improbable or unsound easily refuted, interpretations of markings already observed will, in the interests of the advancement of thought, be accorded a broadminded consideration.

What is possible on a small scale is equally possible on any scale necessity may prescribe.

APPENDIX

Horse-power needed on Venus

The area of Venus' hemisphere equals, say, 92,000,000 sq. miles, out of which 24,000,000 sq. miles could probably be partly irrigated from water conveyed in open channels. These areas would be in the shadow of the cloud canopy and so would ordinarily not show.

The area to be irrigated by a pumped supply may be put at about 15,000,000 sq. miles thus made up—

	sq. miles.
8 spokes each 5000 miles long and $\frac{500}{2}$ miles wide =	10,000,000
Other shaded areas—say	5,000,000
Total ...	15,000,000

To cover which area with water to a depth of 18 ins. in 12 mundane months we should need a continuous flow of 20,000,000 cusecs.

If this flow was passed at a rate of 100 cusecs per pipe through pipes or conduits 6 ft. in diameter, we should need 200,000 such pipes or conduits. In each finger-like marking there would thus, to begin with, be $\frac{200000}{8} = 25{,}000$ such pipes, which if placed 100 ft. apart would cover a width of 2,500,000 ft. or something under 500 miles.

The head of water to which a pipe could be safely subjected on Venus may be taken to be the same as on Earth, 300 ft., and other calculations also made from our hydraulic formulæ.

The head required in a 6 ft. diameter pipe having a flow of 100 cusecs to overcome the friction therein is 1 in 1800, the pumping stations could thus be placed $1800 \times 300 = 540{,}000$ ft. apart on a level pipe—or say, to be on the safe side, they would have on the average to be 100 miles apart on a line carried over hill and dale.

The average length of each 6 ft. pipe line would be $\frac{5000}{2} = 2500$ miles—we should therefore require, say, on the average 25 stations on each pipe.

The H.P. needed at each station would be—

$$\frac{300 \times 100 \times 60 \times 62{\cdot}4}{33{,}000} = 3400 \text{ H.P.}$$

The H.P. needed per pipe would thus on the average be $3400 \times 25 = 85{,}000$, and as the total number of pipes required is under our assumed conditions, 200,000, the total power needed to work the entire system would be 17,000,000,000 H.P. With smaller-sized pipes it would be, of course, somewhat greater.

THE END

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